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The Use of a Reciprocating Handpiece to Create a Glide Path in Curved Canals:
Comparison with Manual Glide Path Preparation

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Key Words: Glide path, reciprocating motion, M4 Safety Handpiece™, stainless steel

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Abstract

Introduction: Prior to introducing rotary instruments into the root canal system, manufacturers recommend creating a glide path to reduce the risk of instrument fracture due to taper lock. This study compared manual preparation of a glide path with mechanical preparation using a reciprocating handpiece in severely curved canals.

Methods: Mesio Buccal roots of eighty-four human maxillary molars with severe curvature (20° - 48°) were selected. The teeth were decoronated and working length established (#6 K-file). Samples were divided into two groups (N=42) according to glide path preparation with K-files #8-20. Group 1: manual preparation, Group 2: mechanical preparation with files in a reciprocating handpiece. Preparation time for each method and incidence of adverse outcomes (file separation, perforation, and ledge creation) were recorded. Group differences were evaluated by the Mann Whitney U test and linear regression of time against curvature angle or length, and proportions of events by Fisher's exact test.

Results: Mean preparation time (seconds): Group 1: 84.4; Group 2: 93.4; Adverse outcomes: Group 1: 3/42 (7.1%); Group 2: 2/42 (4.8%). There was no significant difference between the two tested methods for either median time of preparation, proportions of longer (<150s) preparation times or adverse events, and no significant relationship between curvature of the canal or length and preparation time with either method.

Conclusion : The main source of variance in the time of preparation is likely to be with the clinician, rather than method. The use of a mechanically reciprocating handpiece may be a rational choice for creating an endodontic glide path in curved canals.

Introduction

Endodontic glide path preparation is the initial phase of chemomechanical preparation and is recommended prior to the introduction of rotary instruments (1-3). A properly prepared glide path from canal orifice to the established working length helps to maintain the original canal morphology, leads to fewer canal modifications, and allows for less torque to be applied to rotary instruments thereby reducing the number of file separations (4-9). Glide path preparation is especially critical in curved canals for all of these reasons.

Traditionally a glide path is created manually with small K-files as they are advanced apically within the root canal system. K-files are used to create the glide path due to their size and taper as well as their ability to cut and remove dentin. K-files allow for improved tactile exploration of the canal anatomy and provide the strength and durability to reduce the probability of file separations (9-12). However, instrumentation of curved canals can be a time consuming process, and K-files have been shown to increase instrumentation complications as the file size increases due to the stiffness and tip design (12-13).

The M4 Safety Handpiece™ (SybronEndo, Glendora, CA, USA) is a reciprocating handpiece that can be used with standard handfiles to help mechanically prepare the root canal system. It features a 4:1 gear reduction ratio, and oscillates alternately 30° clockwise and 30° counterclockwise. According to the manufacturer, the reciprocating motion keeps the file loose in the canal, reduces both torsional stress and metal fatigue, and permits safe negotiation while the practitioner controls the apical pressure.

The purpose of the present study was to compare glide path preparation with the M4 Safety Handpiece™ to manual glide path preparation with standard K-files in moderate-severely curved canals. The parameters compared for glide path preparation techniques included: total preparation time (in seconds), the incidence of file separations, and creation of perforations or ledges.

Materials and Methods

This study was approved by the Dwight D. Eisenhower Army Medical Center Research Regulatory Compliance Office, and teeth were collected in accordance with the USA Fort Gordon Dental Activity "Collection of Extracted Teeth" standard operating procedure. Eighty-four de-identified, discarded, extracted human maxillary molars were stored in 1% sodium azide until use. Molars were radiographed to determine maximum canal curvature of the mesiobuccal root. Digital Enterprise Viewing and Acquisition Application software (DEVAA; US Army) was used to enhance the edges of the initial radiographs to better visualize the canal space. The canal curvature (degrees) was determined using the methods described by Schneider (14) and Image J 1.42a/Java 1.6.0-10 image analyzer software (National Institutes of Health, Bethesda, MD). Canals with moderate to severe (14) curvatures between 20° and 48° were identified and equally distributed between the two groups (n=42) and confirmed with statistical analysis.

Root length was standardized to 14mm by decoronating using a diamond rotary disk in a high-speed handpiece. Working length was determined by subtracting 1mm from the length at which a #06 stainless steel K- file (Dentsply Maillefer, Ballaigues, Switzerland) file tip extruded apically.

Group 1: (manual glide path preparation): A glide path was created with stainless steel K- files (Dentsply Maillefer, Ballaigues, Switzerland) in the sequence #08-10-15-20.

Group 2: (M4 Safety Handpiece™): A glide path was created by inserting stainless steel K- files) in the sequence #08-10-15-20 into the M4 Safety Handpiece™ powered with a DTC Endodontic Torque Control Motor (Tulsa Dentsply, Johnson City TN, USA) at a ratio of 1:10,000 rotations per minute with MAX Torque , as recommended by the manufacturer.

Both groups were irrigated intermittently with 2.0ml of 6% sodium hypochlorite (Vista Dental Products, Racine, WI) throughout the instrumentation process. Patency was confirmed with a #06 stainless steel K- file at the completion of instrumentation.

Assessment of glide path preparation

The total preparation time (seconds) for creation of the glide path was recorded, starting with the insertion of the #8 K-file into the canal, and including time for instrumentation, irrigation and changing files. Preparation time was concluded when the #20 K-file was instrumented to working length. Adverse outcomes (perforations, ledges and file separations) were recorded.

Statistical Analysis

GraphPad Prism 6.0 software (GraphPad Software, LaJolla, CA) was used for the statistical analysis. Normality of the distribution of values within each treatment group was tested with the D'Agostino & Pearson omnibus and Shapiro-Wilk normality tests. The Mann-Whitney U test was used to compare the two groups for differences in the median time of preparation and Fisher's exact test was used to analyze treatment

groups for a difference between proportions of longer preparation times. Alpha was 0.05.

Results

The two groups had almost identical mean and standard deviation values for the canal angle (manual, $32.4^{\circ} \pm 7.8^{\circ}$; M4 $32.6^{\circ} \pm 7.8^{\circ}$) and length (manual 11.3 ± 1.3 ; M4 11.5 ± 1.1), consistent with randomization of teeth between the two groups.

Adverse outcomes

File Separation: *Group 1:* 1/42; *Group 2:* 0/42. **Ledge formation:** *Group 1:* 2/42; *Group 2:* 2/42; **Perforations:** *Group 1:* 0/42; *Group 2:* 0/42. There was no significant difference between the groups in the proportion of file separations, ledge formation or perforations ($p=0.36$).

Glide Path Preparation Time: Mean value *Group 1:* 84.4 seconds; *Group 2:* 93.4 seconds. The distributions were not normal, with a skewing to lower times, but with an overall similar shape and no support for bimodality (Figure 2 and Supplemental Information). The groups had identical median values of 85 seconds, and there was no significant difference between the groups (Mann-Whitney U test; $p=0.15$; two-tailed test). Linear regression was used to test the null hypothesis that one line would fit both treatment groups for the relationship between time of preparation and canal angle (Figure 3). Little relationship was found between preparation time and angle, and no difference between the groups ($p=0.40$; $R^2=0.082$).

Discussion

The introduction of rotary instrumentation has revolutionized the field of endodontics by speeding up the process of cleaning and shaping the root canal system, decreasing operator fatigue, increasing dentin and bacterial removal and providing a predictable shape for obturation. However rotary instrumentation is not free from possible adverse events. Due to the possibility of procedural mishaps i.e. separated files, canal transportation and ledge formation, most manufacturers recommend that a glide path be created prior to introducing rotary files into the root canal system. The present study compared two methods of preparing an endodontic glide path in moderate-to-severely curved canals; manually using hand files and mechanically using a reciprocating handpiece. No significant differences between manual preparation and glide path preparation with the M4 Safety Handpiece™ were found for time of preparation or adverse outcomes. In the present study, use of the M4 Safety Handpiece™ did not reduce total preparation time, likely due to the amount of time required to transition between files as the apical file size was increased; interchanging files in the handpiece tended to slow-down the continuation of the instrumentation process.

With the recent introduction of reciprocating systems such as WaveOne™ and Reciproc™ the amount of time required for instrumentation has been reduced, file separations have decreased (15) and there has been an increase in centering ability during instrumentation (16) when compared to traditional rotary methods. The reciprocating motion is thought to be advantageous due to the physical law of action and reaction, which results in a balanced force (17). Although the M4 Safety

Handpiece™ utilizes an oscillating 30° clockwise and 30° counterclockwise motion, the principle movement of reciprocation is in effect during its glide path creation.

The present study found no difference between methods in the total amount of preparation time or frequency of adverse events. Other studies comparing mechanical to manual glide path preparation using various rotary files have reported that creation of a glide path can be completed faster, maintain the original canal morphology more predictably and reduce the amount of post-operative pain when completed mechanically with PathFiles™ and/or ProGlider™ (Dentsply Maillefer, Ballaigues, Switzerland) (18-21). Although our current study did not show a decrease in the amount of time to create a glide path using M4 Safety Handpiece™, this method has the potential to reduce operator fatigue when dealing with severely curved canals or restricted canals due to the mechanical reciprocating movement all while minimizing torsional and flexural stresses on the file, and therefore could be advantageous. Future studies comparing mechanical glide path preparation using the M4 safety handpiece and other rotary files should be evaluated.

It has been argued that the clinician's tactile sense decreases the likelihood of file separations or perforations (12) when manually creating a glide path can. The present study however, found no significant difference between manual preparation and M4 Safety Handpiece™ glide path preparation for the proportion of adverse outcomes. This was possibly due to the number of samples examined, but a post-hoc power analysis indicated several hundred samples would be required to detect a likely small difference. Future studies evaluating the M4 Safety Handpiece™ and its ability to

create a glide path in restricted canals such as pulp canal obliteration should be explored.

Conclusions

Within the limits of this study, from a clinical perspective the M4 Safety Handpiece™ could be a rational choice for creating an endodontic glidepath in curved canals. There was no significant difference to manual preparation in the time required to prepare a glide path and no increased incidence of adverse events. The main source of variance in the time of preparation is likely to be with the clinician and the ability to exchange files with the M4 Safety Handpiece™.

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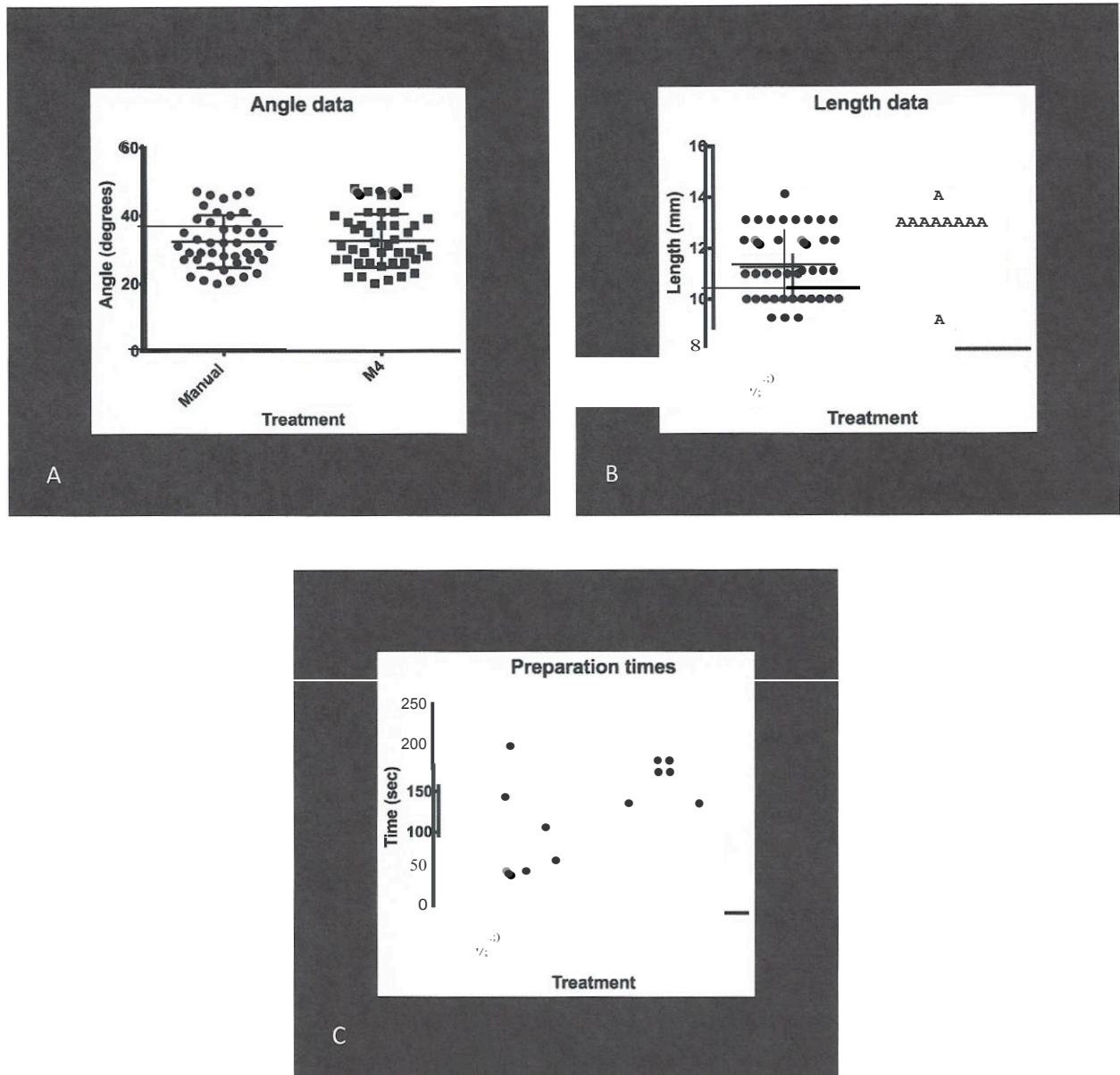


Figure 1: Distribution data for angle, length and time measurements in each treatment group.

Figure 1A: A Scatter plot of values for angle (in degrees) for each sample in each group is shown, with the mean (large bar) and standard deviation (smaller bars). **Figure 1B:** A Scatter plot of values for length (in mm) for each sample in each group is shown, with the mean (large bar) and standard deviation (smaller bars). **Figure 1C:** A Scatter plot of values for time (in seconds) for each sample in each group is shown, with the median (large bar) and interquartile range (smaller bars).

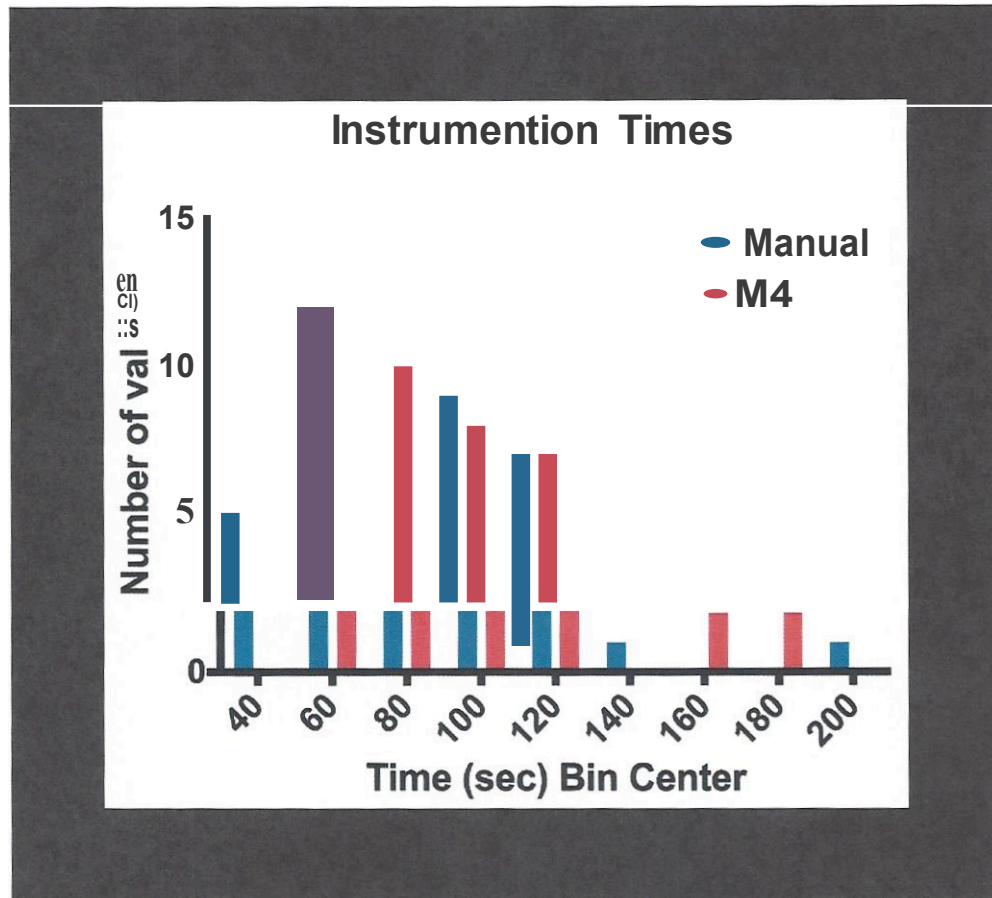


Figure 2: Histogram of data for time measurements in each treatment group. Cumulative values allocated into a bin size of 10 are plotted for each treatment group. In Group1, there was a 10 second gap between 17 values 64 seconds and below, and 22 values 74 seconds and above. In Group 2, there was a 26 second gap between 37 values 127 seconds and lower, and four values 153 seconds and higher. However, Hartigans's dip test for bimodality showed no support for non-unimodality in either the manual ($D = 0.069752$, $p\text{-value} = 0.14$) or the M4 group ($D = 0.051829$, $p\text{-value} = 0.55$). Therefore non-parametric testing of median values was valid.

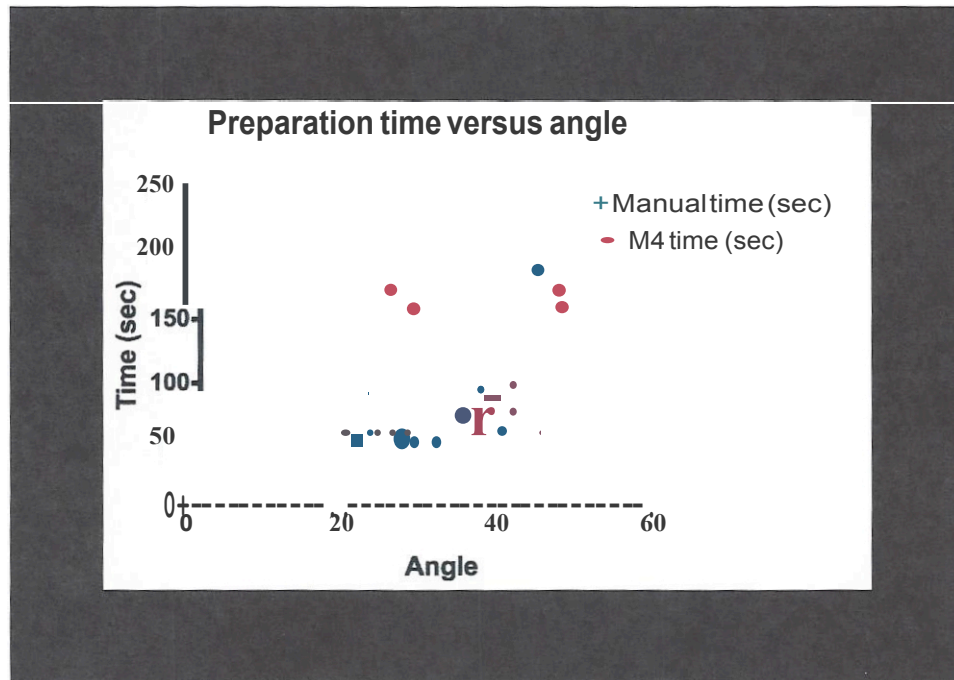


Figure 3: Plot of data for time measurements in each treatment group against canal angle (degrees). The green line shows a linear regression fit to the combined group data. Overall, there was little relation between time and angle (R^2 0.082), and no significant difference between the groups ($p=0.40$). Although four data points were above 150s in Group 2 and only one in Group 1, the differences in proportions of longer times were not significant (Fisher's exact $p=0.36$).

The Use of a Reciprocating Handpiece to Create a Glide Path in Curved Canals: Comparison with Manual Glide Path Preparation

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Supplemental Information

Statistical Analysis

The data were inspected for randomization between the groups and for the distribution patterns. In the test employed, if the skewness numerical value was >1 , the skewness was substantial. A normal distribution would have a kurtosis value of zero. We sought to answer four questions by statistical testing: is there a significant difference in preparation time between the two methods tested; is there a significant difference in the proportion of adverse events; is there a difference in the proportion of teeth requiring a longer time; and is there a relationship between canal angle and preparation time?

1) Descriptive statistics:

Inspection of the scatter plots for the angle data from the two treatment groups (Figure 1A) showed a relatively uniform distribution with no obvious outliers. Angle data from both groups passed both the D'Agostino & Pearson omnibus normality and Shapiro-Wilk tests for normality ($p > 0.06$), with similar modest values for positive skewness and comparable moderate values for negative kurtosis. The two groups had almost identical values for the mean and standard deviations (manual 32.4 ± 7.8 ; M4

32.6±7.8). This was consistent with randomization of teeth between the two groups for angle.

Inspection of the scatter plots for the length data from the two treatment groups (Figure 1B) showed a relatively uniform distribution across six discrete sizes (in mm), with no apparent outliers. Length data from both groups passed the D'Agostino & Pearson omnibus normality test, but both groups failed the Shapiro-Wilk normality test ($p < 0.01$), with similar low values for positive skewness and comparable moderate values for negative kurtosis. The two groups had almost identical values for the mean and standard deviations (manual 11.3±1.3; M4 11.5±1.1). Collectively, these data were consistent with randomization of teeth between the two groups for length.

Inspection of the scatter plots for the preparation time data from the two treatment groups (Figure 1C) showed a more complex pattern, with indications of a skewing of the distribution towards lower values, and possible bimodality. In the manual group, there was a 10 second gap between 17 values 64 and below, and 39 values 74 and above (Figure 2). In the M4 group, there was a 26 second gap between 37 values 127 and lower, and four values 153 and higher. However, Hartigan's dip test for bimodality implemented in R showed no support for the alternative hypothesis of non-unimodality in either the manual ($D = 0.069752$, $p\text{-value} = 0.14$) or the M4 group ($D = 0.051829$, $p\text{-value} = 0.55$).

The time of preparation for the two treatment groups failed both tests for normality ($p < 0.012$), with substantial positive skew (manual 0.96, M4 1.15), and high

positive kurtosis (1.15) in the M4 group. The groups had identical median values of 85 seconds, with an interquartile range of 54-109 seconds in the manual group, and 69-115 in the M4 group. Inspection of the histogram for value distributions showed an overall similar distribution shape, indicating non-parametric testing of central values would be valid.

2) Inferential statistics

The Mann-Whitney U test was used to compare the two groups for differences in the median time of preparation. As anticipated from the identical median values, there was no significant difference between the groups ($p=0.15$; two-tailed test).

Inspection of the scatterplot of preparation time against canal angle showed no evident difference between the treatment groups, although four data points were above 150s in the M4 group and only one in the manual group. However, Fisher's exact test showed no significant difference ($p=0.36$) between the treatment groups for the proportion of longer times.

There was no significant difference in the proportion of file separations as determined using Fisher's exact test (1/41 manual; 0/42 M4; $p=1.0$) or ledge formation (2/41 manual; 2/42 M4; $p=1.0$).

Linear regression was used to test the null hypothesis that one line would fit both treatment groups for the relationship between time of preparation and canal angle. The conclusion ($\alpha=0.05$) was that the null hypothesis should not be rejected ($p=0.40$). However, R^2 was only 0.082, indicating a minimal relationship between time of preparation and canal angle.

Similarly, linear regression was used to test the null hypothesis that one line would fit both treatment groups for the relationship between time of preparation and canal length. The conclusion ($\alpha = 0.05$) was that the null hypothesis should not be rejected ($p = 0.26$). However, R^2 was only 0.022, indicating almost no relationship between time of preparation and canal length.